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United States Patent [19]

Levitas et al.

[11] Patent Number: 6,053,887

[45] Date of Patent: *Apr. 25, 2000

[54] **MEDICAL TREATMENT APPARATUS AND METHOD**

[75] Inventors: **Doron Levitas**; **Shan Padda**, both of Chicago, Ill.; **Alan E. Jordan**, San Diego, Calif.; **Sam Russo**, Lisle, Ill.; **Larry Wilson**, Poway, Calif.

[73] Assignee: **Baxter Healthcare Inc.**, Deerfield, Ill.

[*] Notice: This patent is subject to a terminal disclaimer.

[21] Appl. No.: **09/206,075**

[22] Filed: **Dec. 4, 1998**

Related U.S. Application Data

[63] Continuation of application No. 08/703,543, Aug. 27, 1996, Pat. No. 5,895,371.

[51] **Int. Cl.**[7] **A61M 31/00**

[52] **U.S. Cl.** **604/49**; 604/65

[58] **Field of Search** 604/65, 66, 67, 604/49, 50, 151, 152, 153, 154, 155

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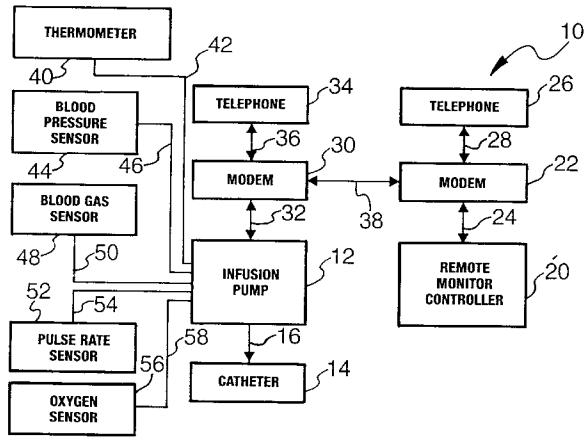
Primary Examiner—Michael Buiz
Assistant Examiner—Daphna Shai
Attorney, Agent, or Firm—Perry Hoffman

[57] **ABSTRACT**

A medical treatment apparatus is provided with a programmable medical device disposed at a first room location and a remote monitor and/or controller disposed at a second room location. The programmable medical device is used to administer a medical treatment to a patient, and the remote monitor/controller maybe used to monitor the operation of the medical device, control the operation of the medical device, and/or to transfer data from the medical device to the remote monitor/controller. The apparatus may allow voice communication between the remote monitor/controller and the patient who is receiving treatment via the medical device while the medical device is being monitored and/or controlled from the remote location. The remote monitor/controller may also include means for determining the type of medical device to which it is connected. The programmable medical device includes various types of sensors for generating patient medical condition data which is transmitted to the remote monitor/controller. The medical treatment provided to the patient can be changed in response to analysis of the patient medical data at the remote location.

15 Claims, 13 Drawing Sheets



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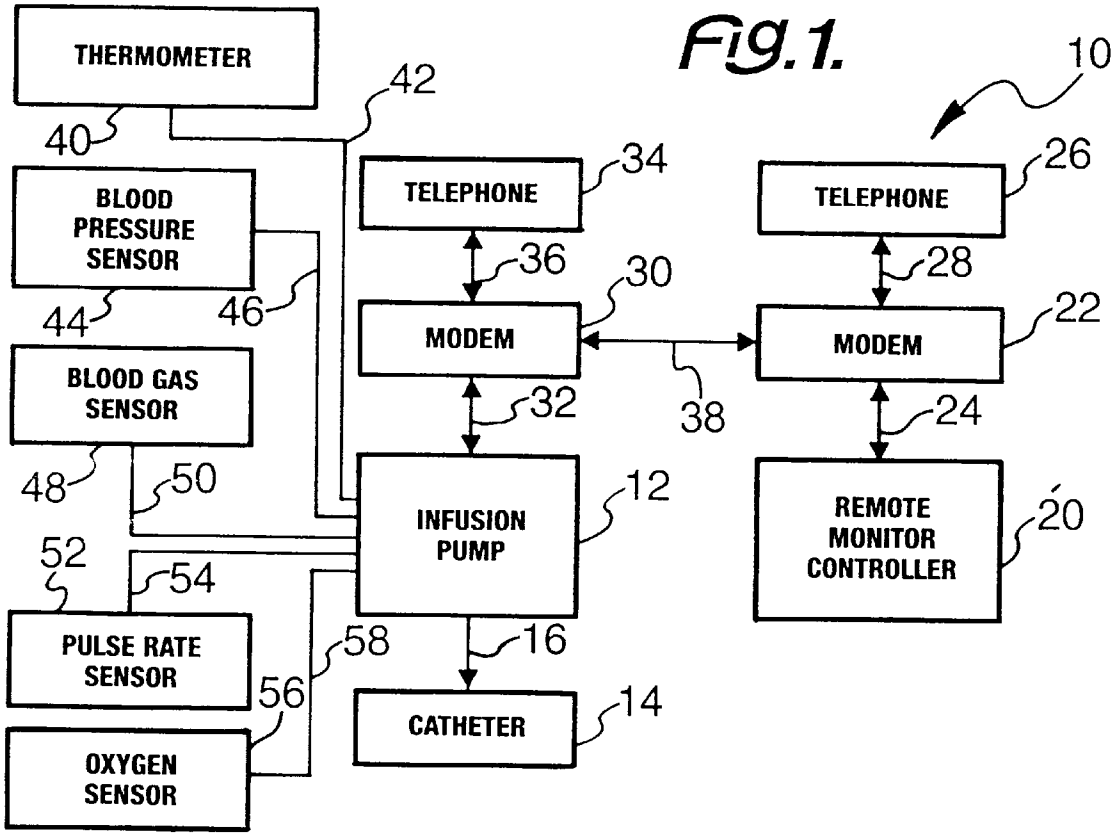
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42
40
BLOOD PRESSURE SENSOR
44
46
BLOOD GAS SENSOR
48
50
52
54
PULSE RATE SENSOR
56
58
OXYGEN SENSOR
TELEPHONE
34
36
MODEM
30
32
INFUSION PUMP
12
16
CATHETER
14
38
10
TELEPHONE
26
28
MODEM
22
24
REMOTE MONITOR CONTROLLER
20

Fig.1.

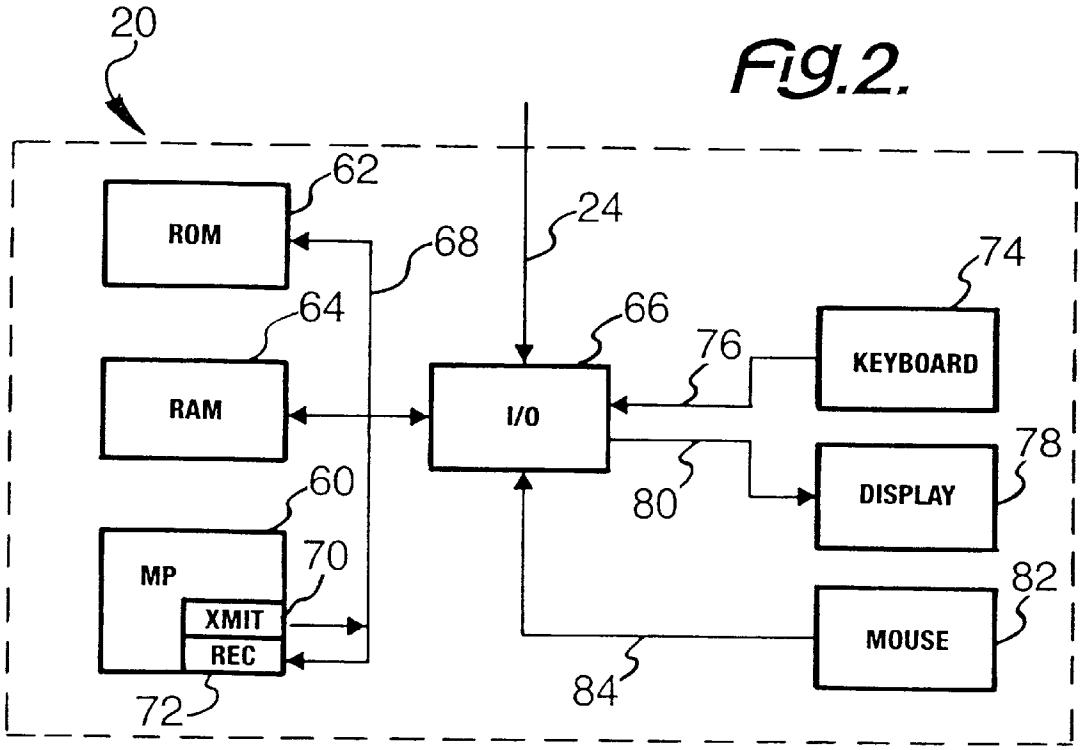

20
ROM
62
68
24
74
64
66
76
RAM
I/O
KEYBOARD
78
80
DISPLAY
60
MP
70
XMIT
REC
72
82
MOUSE
84

Fig.2.

Fig.3.

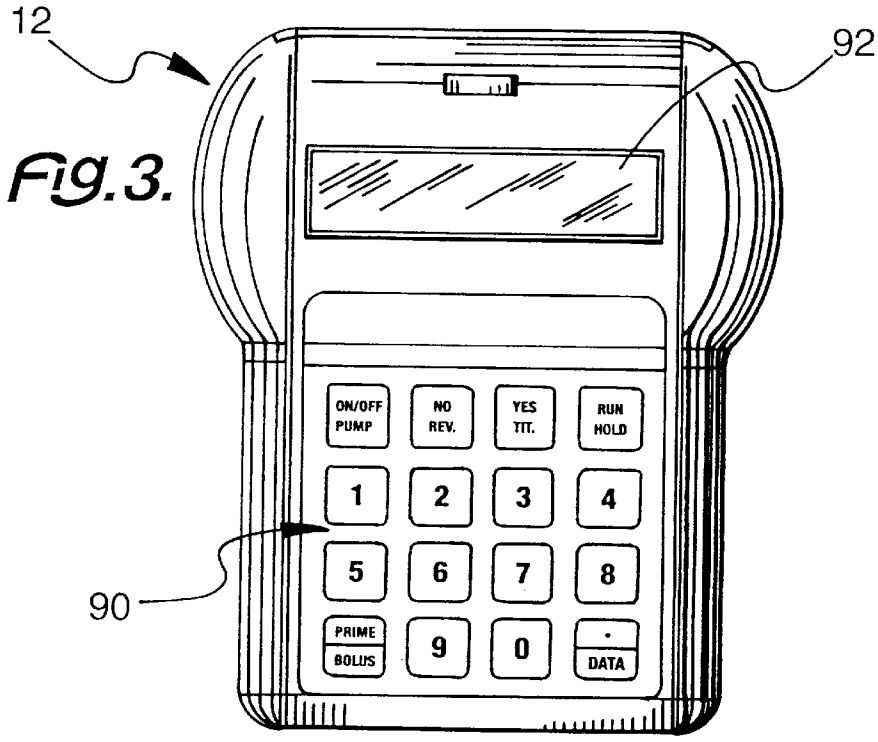

12
92
90
ON/OFF PUMP
NO REV.
YES TIT.
RUN HOLD
1
2
3
4
5
6
7
8
PRIME BOLUS
9
0
.
DATA

Fig.4.

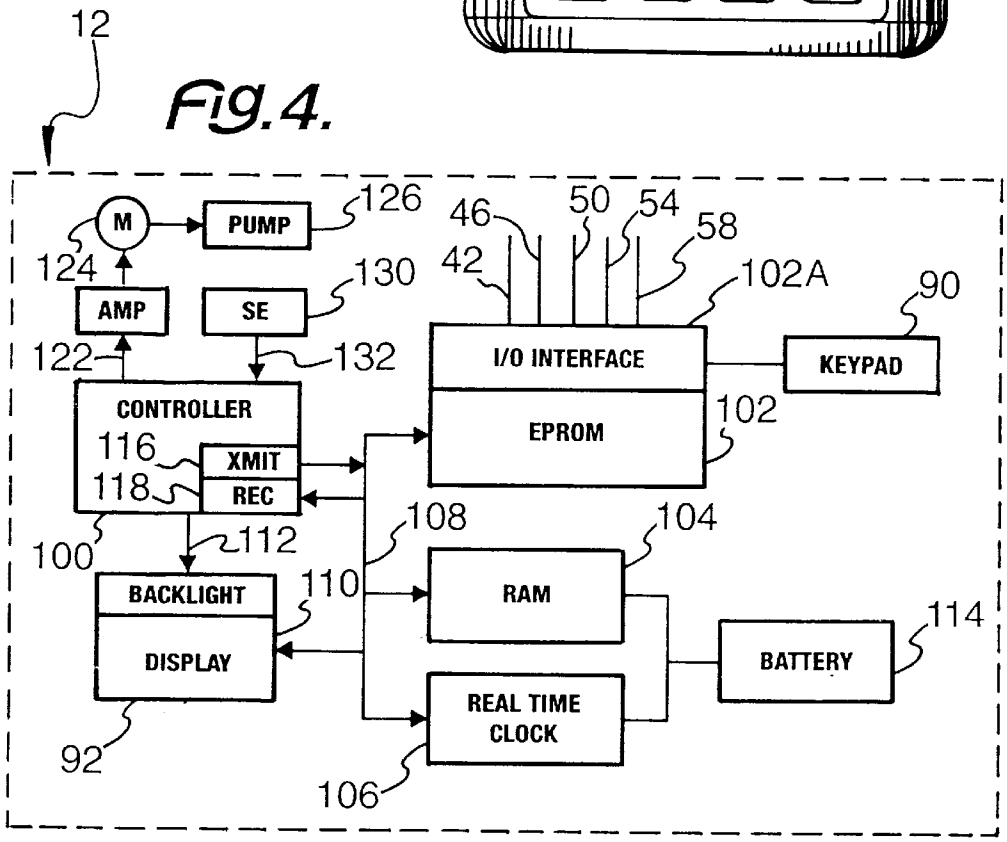

12
M
PUMP
126
124
AMP
SE
130
122
132
CONTROLLER
116
XMIT
118
REC
100
112
BACKLIGHT
DISPLAY
92
110
46
50
54
58
42
102A
90
I/O INTERFACE
KEYPAD
EPROM
102
108
104
RAM
BATTERY
114
REAL TIME CLOCK
106

Fig. 5.

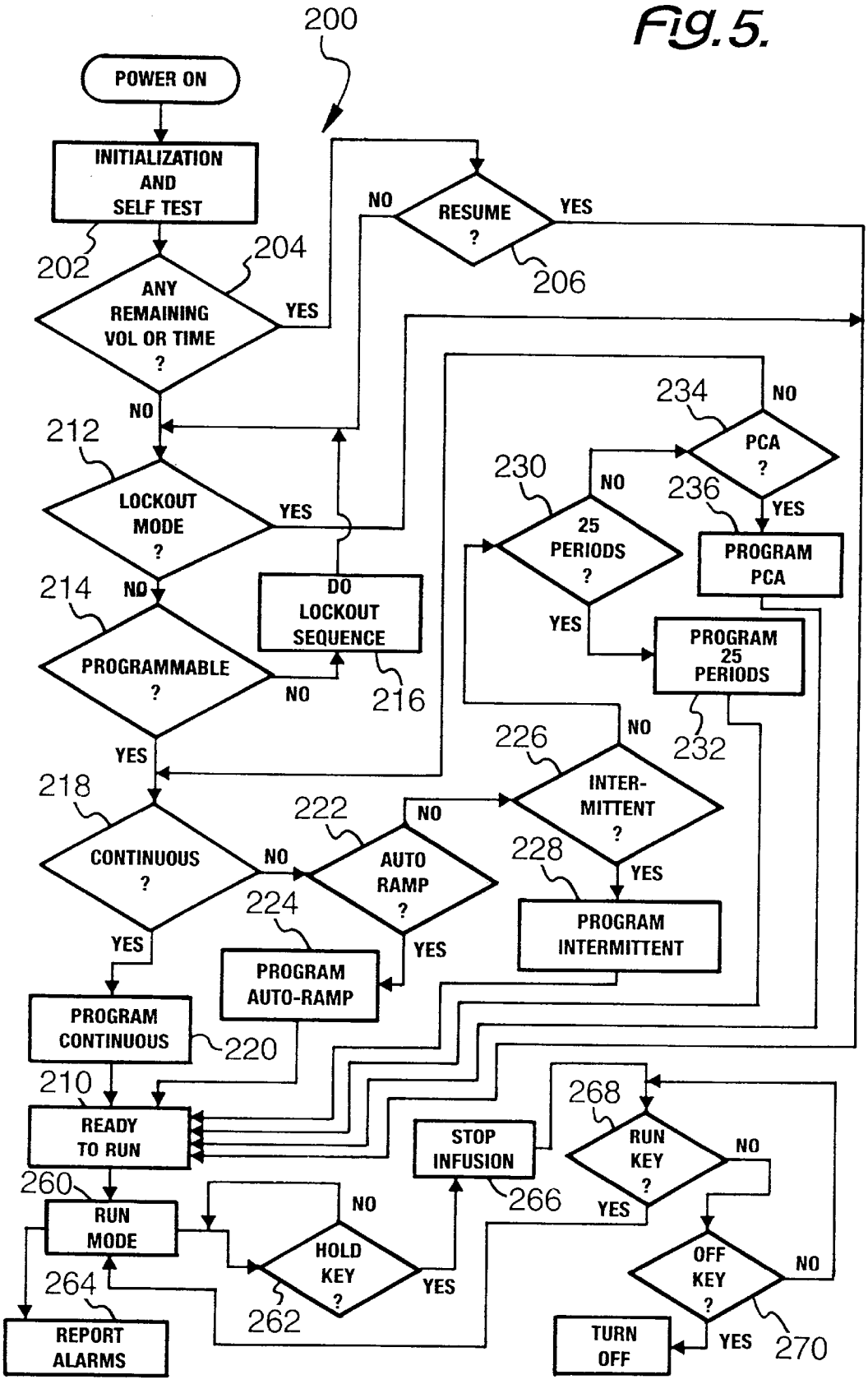

200
POWER ON
INITIALIZATION AND SELF TEST
202
204
ANY REMAINING VOL OR TIME ?
YES
NO
RESUME ?
YES
NO
206
212
LOCKOUT MODE ?
YES
NO
DO LOCKOUT SEQUENCE
216
214
PROGRAMMABLE ?
NO
YES
218
CONTINUOUS ?
NO
YES
222
AUTO RAMP ?
NO
YES
224
PROGRAM AUTO-RAMP
PROGRAM CONTINUOUS
220
226
INTER-MITTENT ?
NO
YES
228
PROGRAM INTERMITTENT
230
25 PERIODS ?
NO
YES
232
PROGRAM 25 PERIODS
234
PCA ?
NO
YES
236
PROGRAM PCA
210
READY TO RUN
260
RUN MODE
264
REPORT ALARMS
HOLD KEY ?
NO
YES
262
STOP INFUSION
266
268
RUN KEY ?
NO
YES
OFF KEY ?
NO
YES
270
TURN OFF

Fig.6.

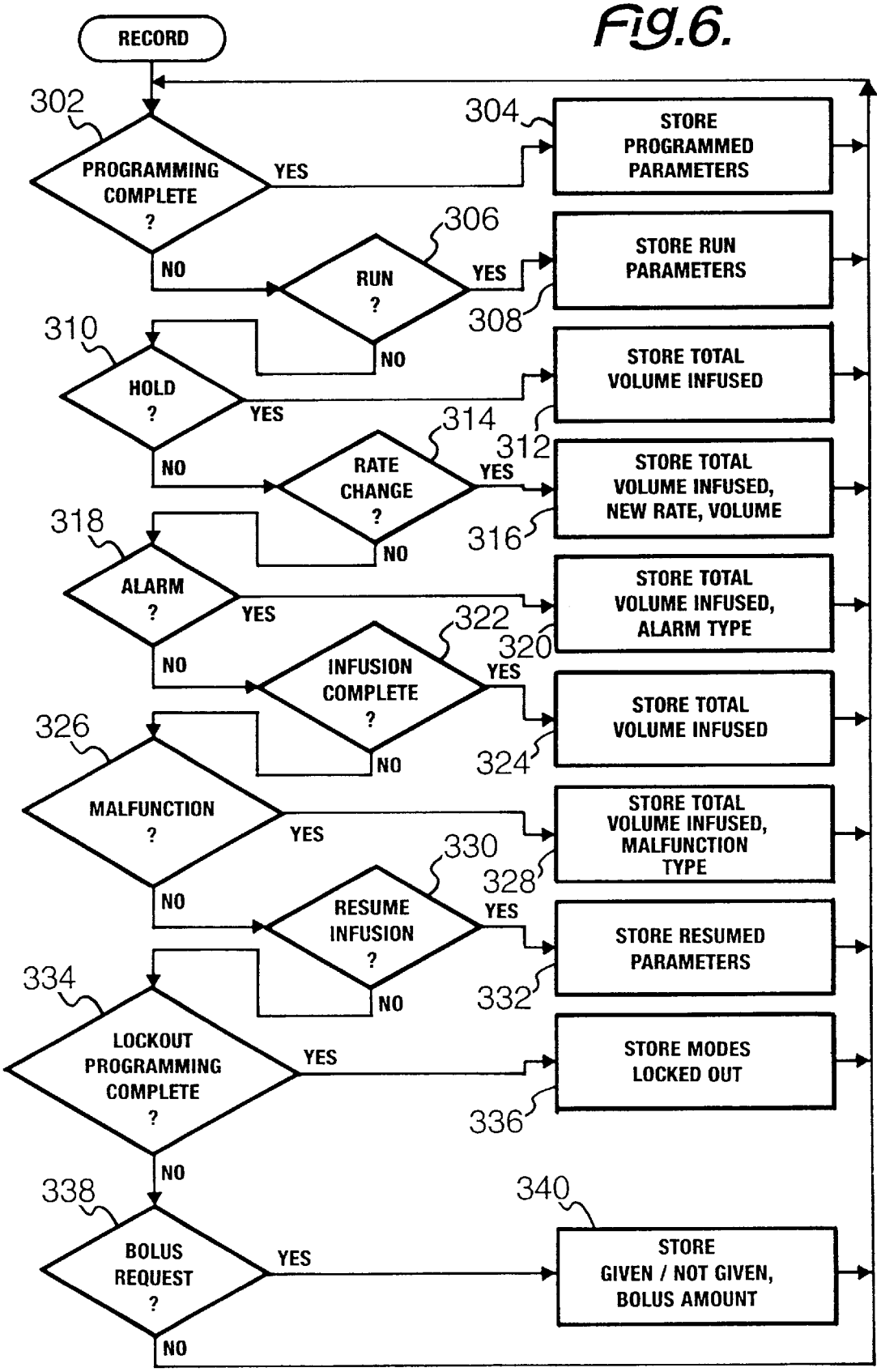
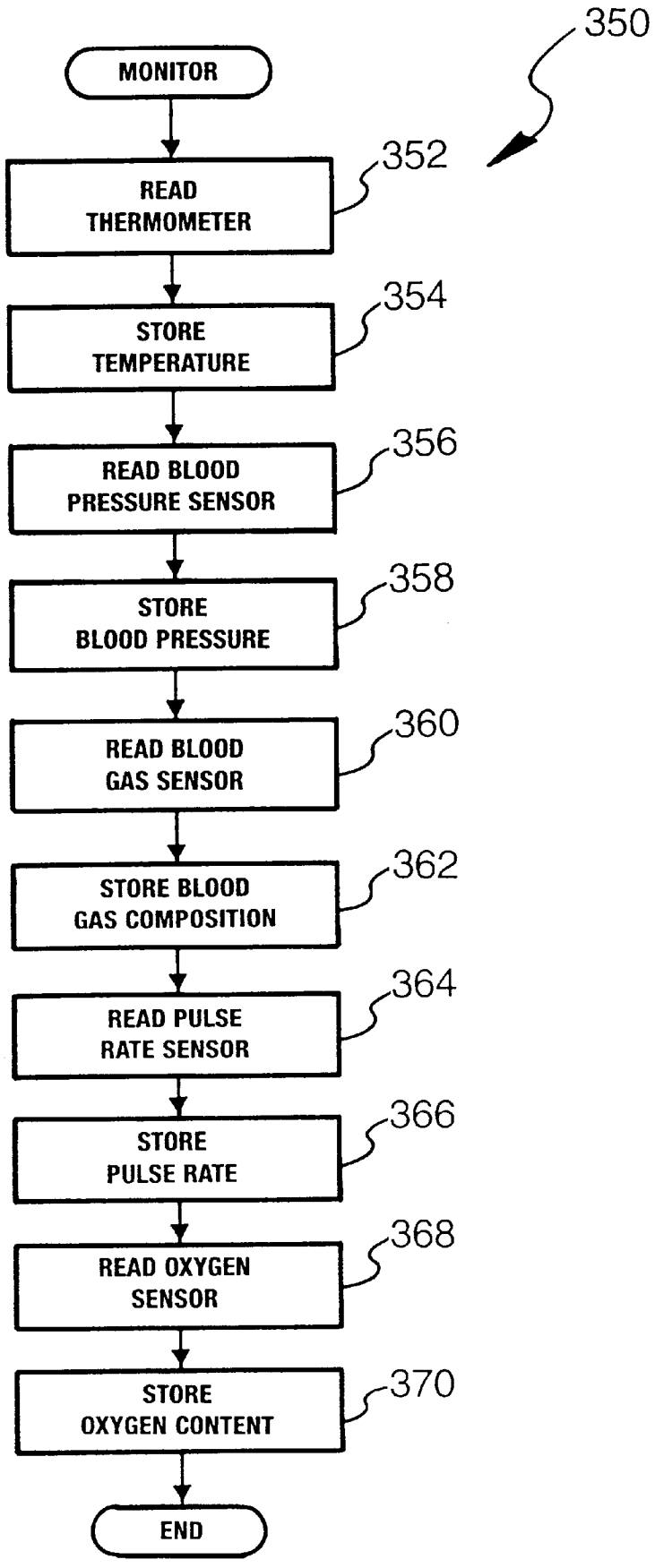

RECORD
302
PROGRAMMING COMPLETE ?
YES
304
STORE PROGRAMMED PARAMETERS
NO
306
RUN ?
YES
STORE RUN PARAMETERS
308
NO
310
HOLD ?
YES
STORE TOTAL VOLUME INFUSED
NO
314
RATE CHANGE ?
YES
312
STORE TOTAL VOLUME INFUSED, NEW RATE, VOLUME
316
NO
318
ALARM ?
YES
STORE TOTAL VOLUME INFUSED, ALARM TYPE
NO
322
INFUSION COMPLETE ?
YES
320
STORE TOTAL VOLUME INFUSED
324
NO
326
MALFUNCTION ?
YES
STORE TOTAL VOLUME INFUSED, MALFUNCTION TYPE
NO
330
RESUME INFUSION ?
YES
328
STORE RESUMED PARAMETERS
332
NO
334
LOCKOUT PROGRAMMING COMPLETE ?
YES
STORE MODES LOCKED OUT
336
NO
338
BOLUS REQUEST ?
YES
340
STORE GIVEN / NOT GIVEN, BOLUS AMOUNT
NO

Fig.6A.


350
MONITOR
READ THERMOMETER
352
STORE TEMPERATURE
354
READ BLOOD PRESSURE SENSOR
356
STORE BLOOD PRESSURE
358
READ BLOOD GAS SENSOR
360
STORE BLOOD GAS COMPOSITION
362
READ PULSE RATE SENSOR
364
STORE PULSE RATE
366
READ OXYGEN SENSOR
368
STORE OXYGEN CONTENT
370
END

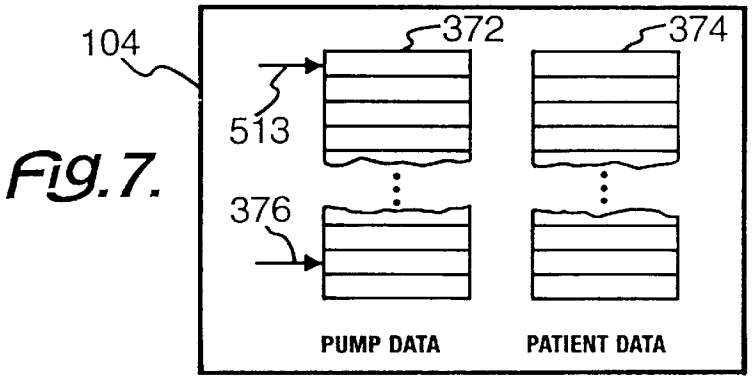

104
372
374
513
376
PUMP DATA
PATIENT DATA

Fig.7.

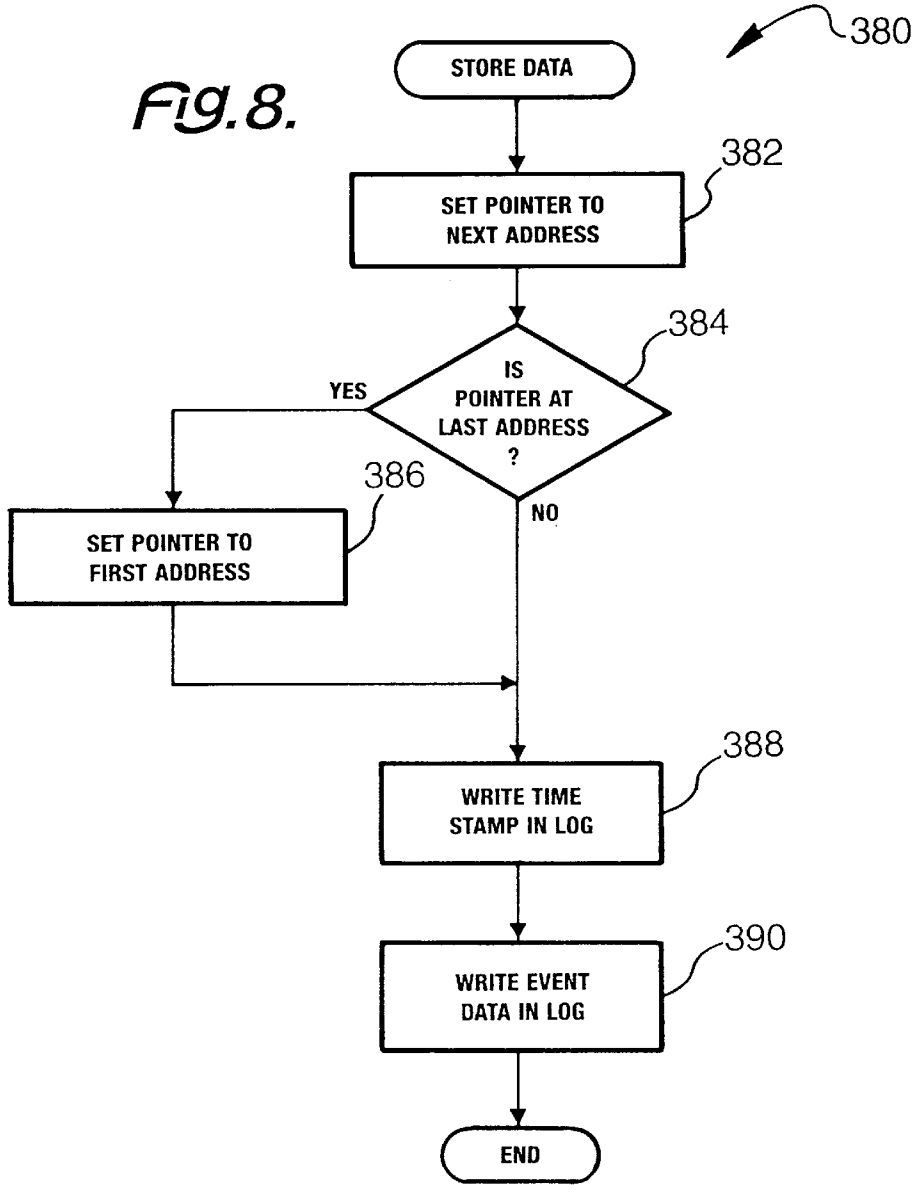

380
STORE DATA
382
SET POINTER TO NEXT ADDRESS
384
IS POINTER AT LAST ADDRESS ?
YES
NO
386
SET POINTER TO FIRST ADDRESS
388
WRITE TIME STAMP IN LOG
390
WRITE EVENT DATA IN LOG
END

Fig.8.

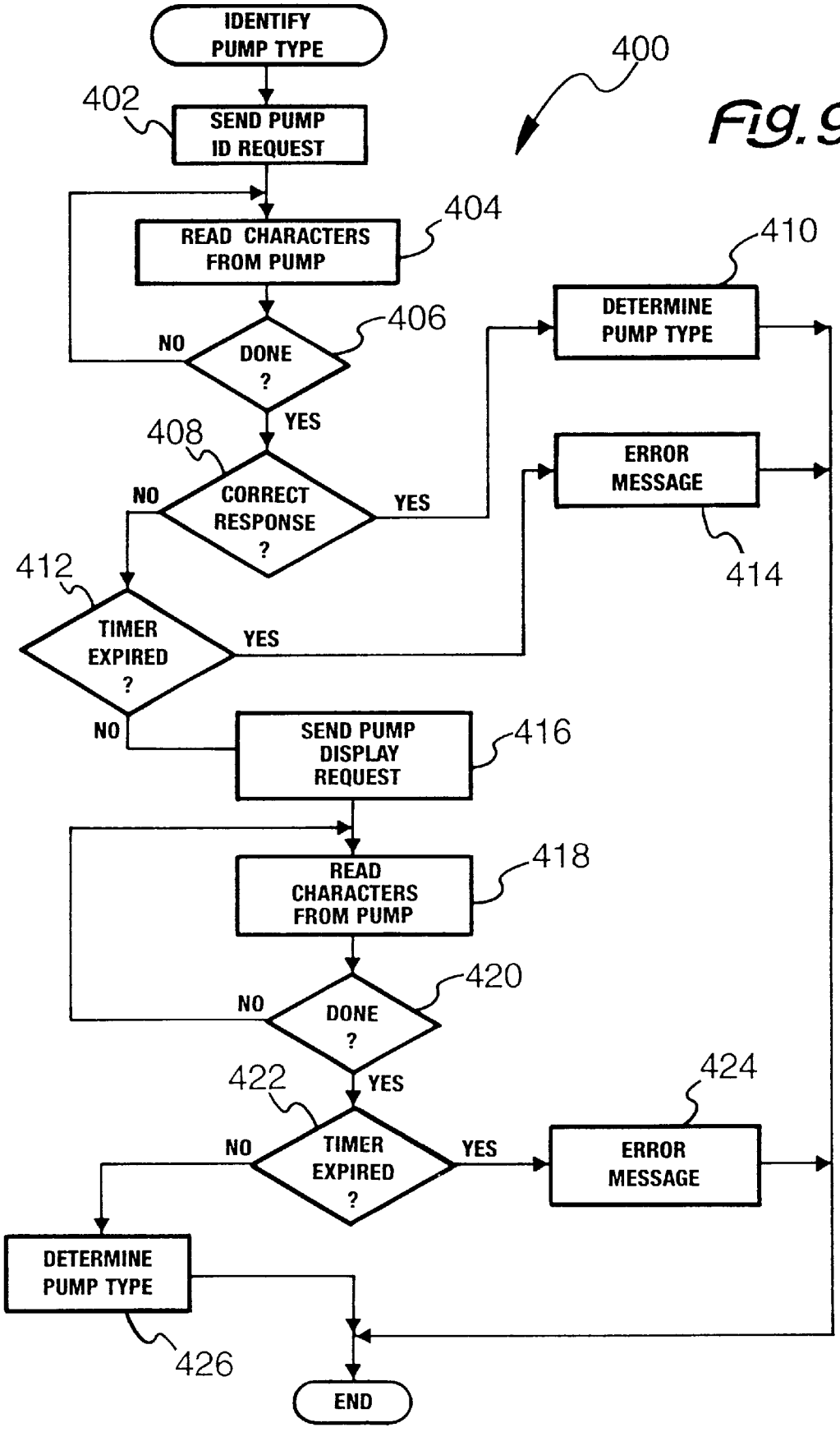

IDENTIFY PUMP TYPE
400
402
SEND PUMP ID REQUEST
READ CHARACTERS FROM PUMP
404
NO
DONE ?
406
YES
408
NO
CORRECT RESPONSE ?
YES
410
DETERMINE PUMP TYPE
ERROR MESSAGE
414
412
TIMER EXPIRED ?
YES
NO
SEND PUMP DISPLAY REQUEST
416
READ CHARACTERS FROM PUMP
418
NO
DONE ?
420
YES
422
NO
TIMER EXPIRED ?
YES
424
ERROR MESSAGE
DETERMINE PUMP TYPE
426
END

Fig. 9.

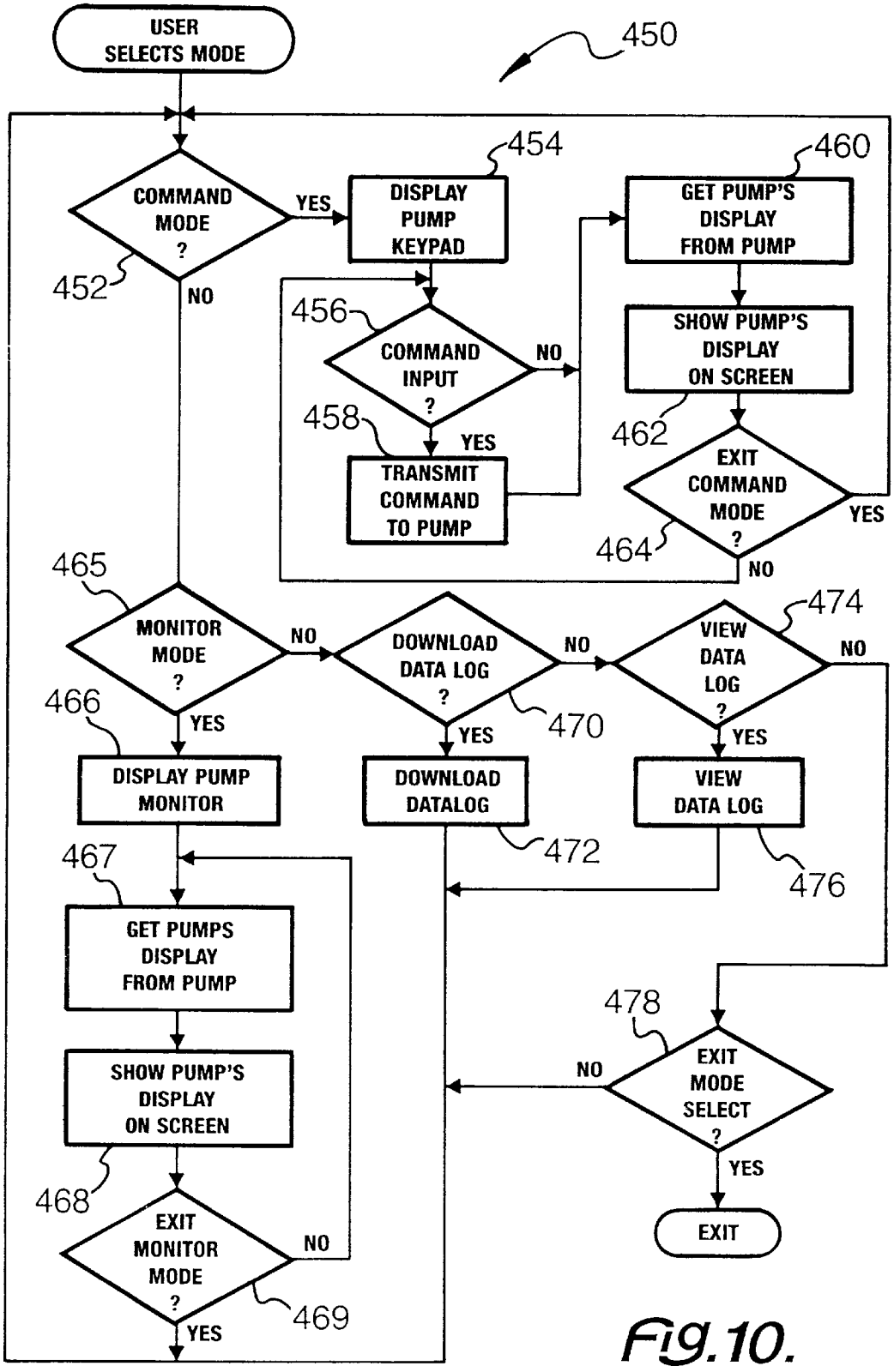

USER SELECTS MODE
450
COMMAND MODE ?
YES
NO
452
DISPLAY PUMP KEYPAD
454
COMMAND INPUT ?
456
NO
YES
458
TRANSMIT COMMAND TO PUMP
GET PUMP'S DISPLAY FROM PUMP
460
SHOW PUMP'S DISPLAY ON SCREEN
462
EXIT COMMAND MODE ?
464
YES
NO
MONITOR MODE ?
465
NO
YES
466
DISPLAY PUMP MONITOR
DOWNLOAD DATA LOG ?
NO
YES
470
DOWNLOAD DATALOG
472
VIEW DATA LOG ?
474
NO
YES
VIEW DATA LOG
476
GET PUMPS DISPLAY FROM PUMP
467
SHOW PUMP'S DISPLAY ON SCREEN
468
EXIT MONITOR MODE ?
NO
YES
469
EXIT MODE SELECT ?
478
NO
YES
EXIT

Fig. 10.

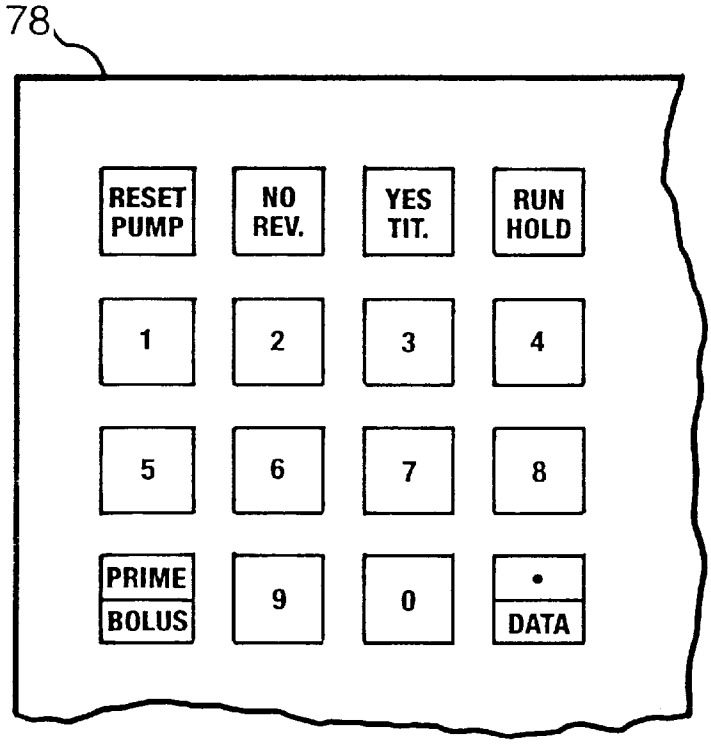


Fig. 11A.

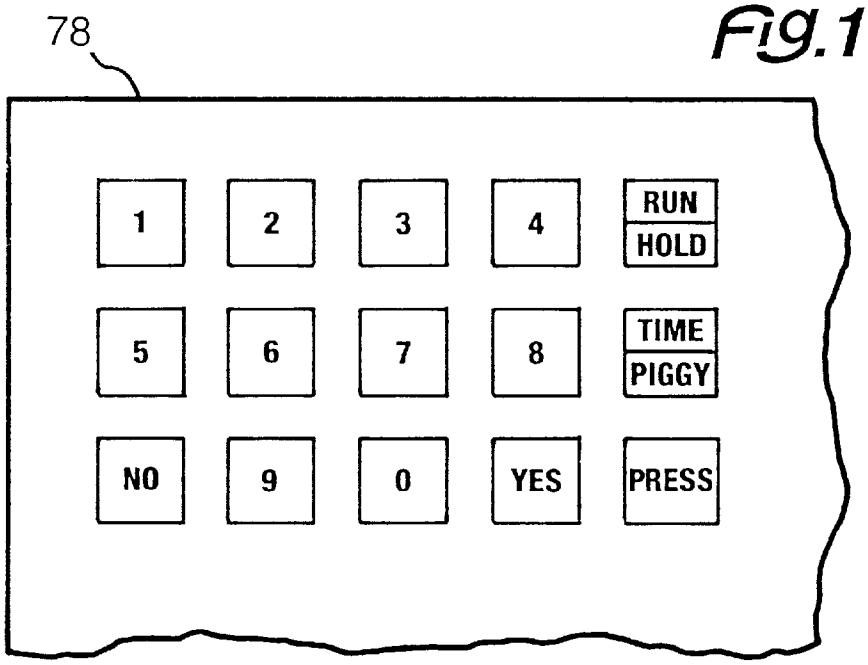


Fig. 11B.

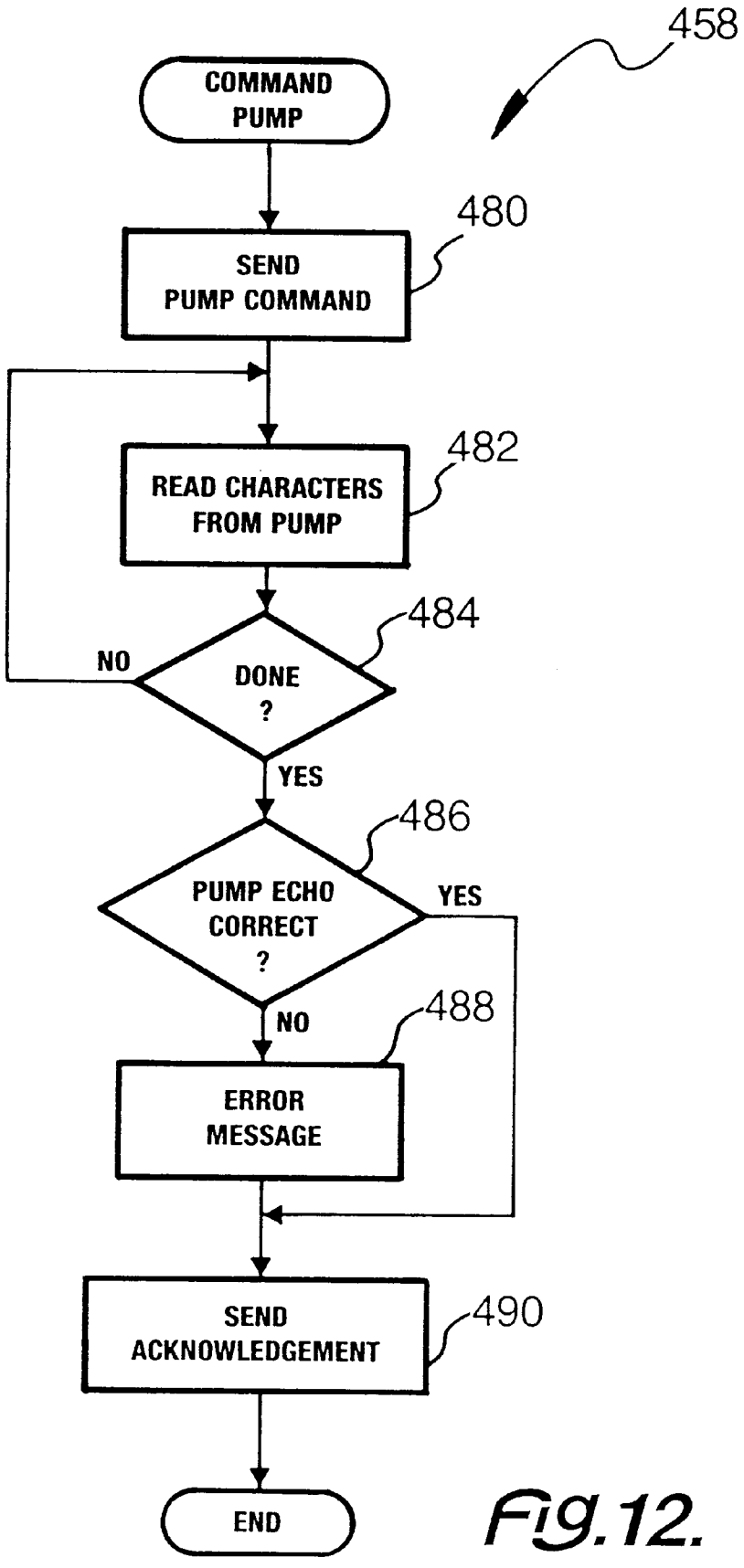

458
COMMAND PUMP
480
SEND PUMP COMMAND
482
READ CHARACTERS FROM PUMP
484
DONE ?
NO
YES
486
PUMP ECHO CORRECT ?
YES
NO
488
ERROR MESSAGE
SEND ACKNOWLEDGEMENT
490
END

Fig. 12.

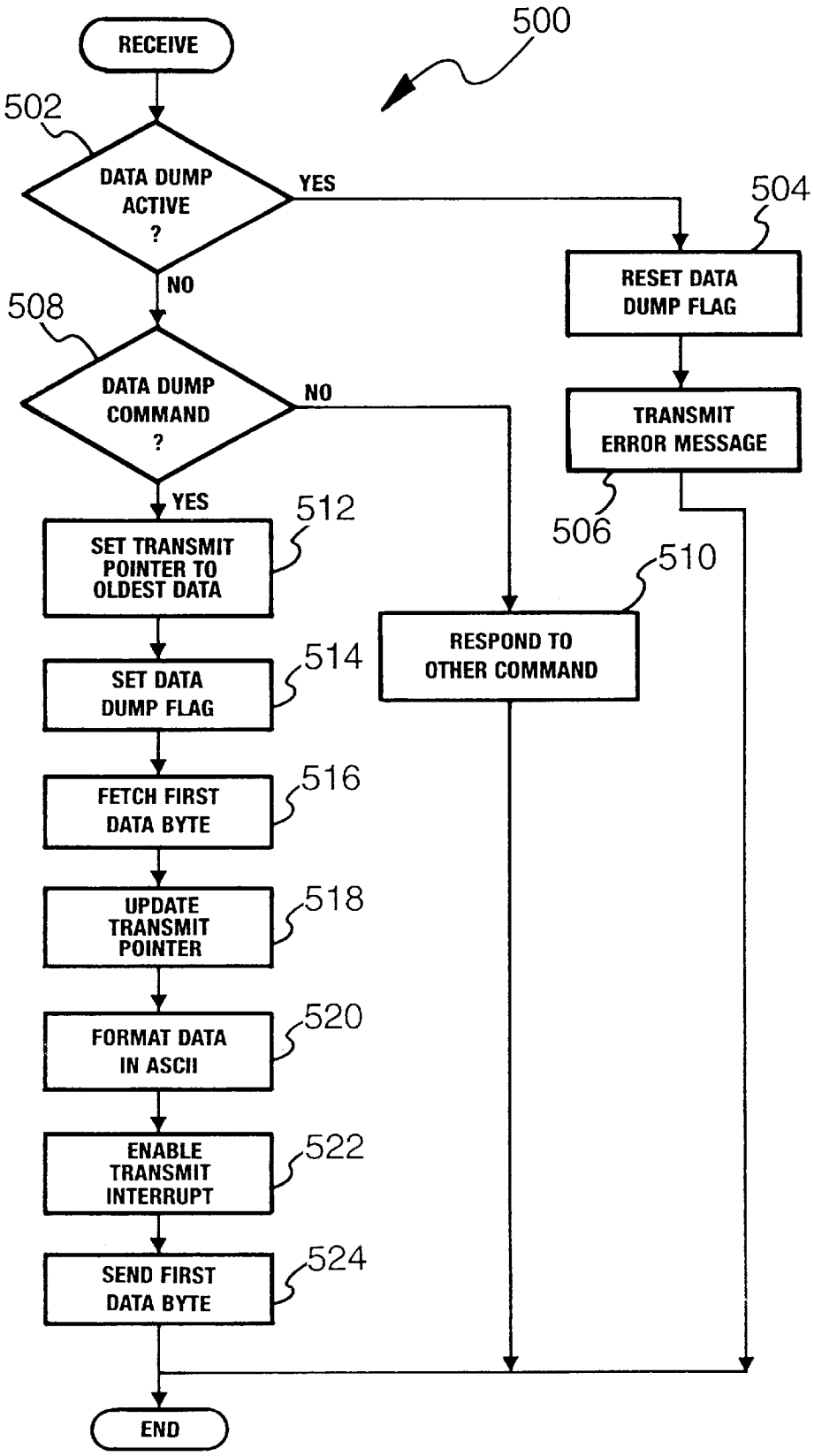

500
RECEIVE
502
DATA DUMP ACTIVE ?
YES
504
RESET DATA DUMP FLAG
NO
508
DATA DUMP COMMAND ?
NO
TRANSMIT ERROR MESSAGE
YES
512
SET TRANSMIT POINTER TO OLDEST DATA
506
510
RESPOND TO OTHER COMMAND
514
SET DATA DUMP FLAG
516
FETCH FIRST DATA BYTE
518
UPDATE TRANSMIT POINTER
520
FORMAT DATA IN ASCII
522
ENABLE TRANSMIT INTERRUPT
524
SEND FIRST DATA BYTE
END

Fig.13.

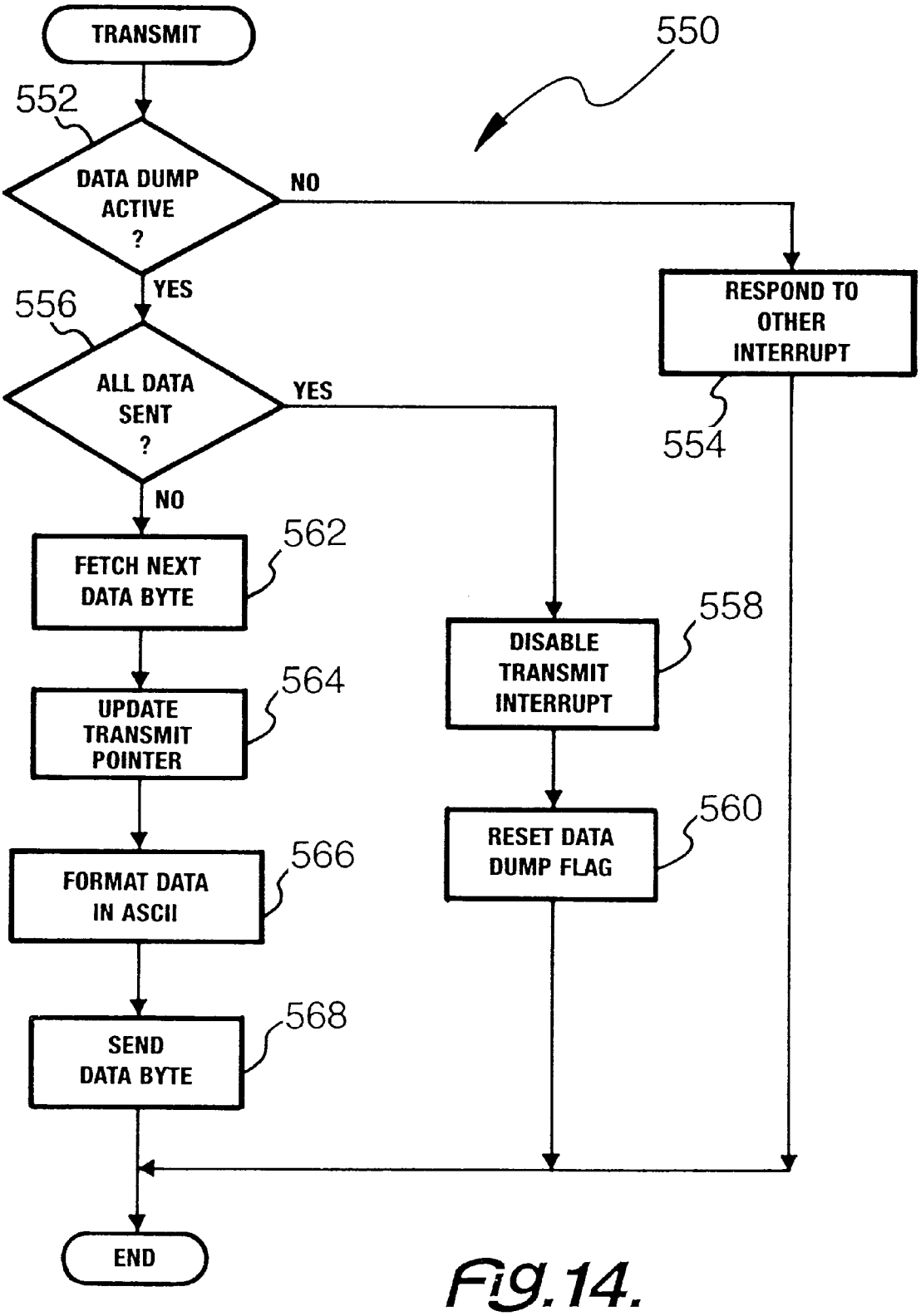
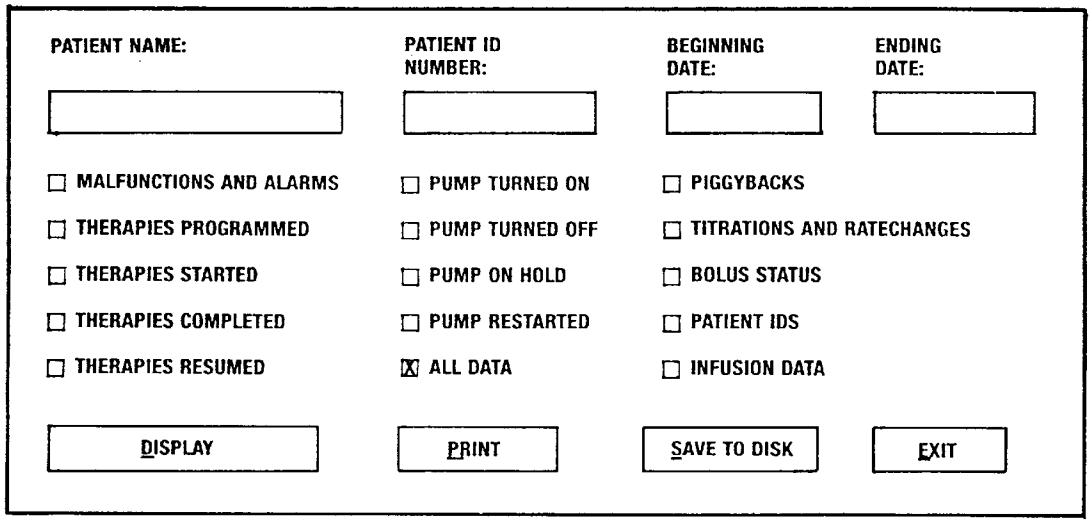

TRANSMIT
550
552
DATA DUMP ACTIVE ?
NO
YES
RESPOND TO OTHER INTERRUPT
554
556
ALL DATA SENT ?
YES
NO
562
FETCH NEXT DATA BYTE
558
DISABLE TRANSMIT INTERRUPT
564
UPDATE TRANSMIT POINTER
560
RESET DATA DUMP FLAG
566
FORMAT DATA IN ASCII
568
SEND DATA BYTE
END

Fig. 14.

Fig.15.


PATIENT NAME:
PATIENT ID NUMBER:
BEGINNING DATE:
ENDING DATE:
☐ MALFUNCTIONS AND ALARMS
☐ THERAPIES PROGRAMMED
☐ THERAPIES STARTED
☐ THERAPIES COMPLETED
☐ THERAPIES RESUMED
☐ PUMP TURNED ON
☐ PUMP TURNED OFF
☐ PUMP ON HOLD
☐ PUMP RESTARTED
☒ ALL DATA
☐ PIGGYBACKS
☐ TITRATIONS AND RATECHANGES
☐ BOLUS STATUS
☐ PATIENT IDS
☐ INFUSION DATA
DISPLAY
PRINT
SAVE TO DISK
EXIT

MEDICAL TREATMENT APPARATUS AND METHOD

This is a continuation, of prior application Ser. No. 08/703,543, filed Aug. 27, 1996 now U.S. Pat. No. 5,895,321 which is hereby incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

The present invention is directed to a medical treatment apparatus and method for automatically administering a medical treatment to a patient via a medical treatment device, such as an infusion pump, disposed at a first location and a monitoring and/or controlling device disposed at a remote location.

An infusion pump is used to automatically administer liquid medicant to a patient. The liquid medicant is supplied from a source of medicant and pumped into the patient via a catheter or other injection device. The manner in which the liquid is infused is controlled by the infusion pump, which may have various modes of infusion, such as a continuous mode in which the liquid medicant is continuously infused at a constant rate, or a ramp mode in which the rate of infusion gradually increases, then remains constant, and then gradually decreases.

Prior art systems have been described which monitor the medical condition of a patient at a patient location using a sensing apparatus which has various types of sensors, such as a sensor for generating heart rate data and a temperature sensor for monitoring the temperature in the ear canal of the patient. Such a prior art system included a remote monitoring device provided at a location remote from the sensing apparatus to which sensing data was transmitted, and the remote monitoring device transmitted control signals to the sensing apparatus at the patient location to control the operation of the sensing apparatus, such as by controlling the sampling rate of the sensors. Such a prior art system also included display means at the remote location for generating visual displays relating to the sensed medical conditions.

One example of such a prior art system is disclosed in U.S. Pat. No. 3,910,257 to Fletcher, et al. That patent discloses a sensing apparatus in the form of a bio-belt unit 11, 12 and a remote monitoring device in the form of a data acquisition unit 14. The bio-belt unit 11, 12 incorporates different types of sensors, including an ear canal sensor 21 and a plurality of ECG electrodes 22. The data acquisition unit 14 receives patient medical data from the bio-belt unit 11, 12 and also transmits control commands to control the operation of the bio-belt unit 11, 12. See e.g. FIG. 2; column 5, lines 1–7; column 6, lines 6–10; and column 6, lines 39–47 of the Fletcher, et al. patent.

U.S. Pat. No. 5,038,800 to Oba also discloses the concept of providing a patient monitoring apparatus at a patient location and a remote monitoring device having the capability of receiving patient medical data from the patient monitoring apparatus and controlling the operation of the patient monitoring apparatus from a remote location. The patient monitoring apparatus is provided as a number of bedside monitors 3A–3C, and the remote monitoring apparatus is provided is in the form of a central monitor 2. The Oba patent discloses that the bedside monitors 3A–3C and the central monitor 2 are interconnected via a local area network (LAN). The operation of the bedside monitors 3A–3C can be controlled from the central monitor 2. See, for example, column 4, lines 4–11; column 4, lines 24–27; and column 4, lines 40–42 of the Oba patent.

U.S. Pat. No. 4,803,625 to Fu, et al. also discloses the concept of providing a patient monitoring apparatus at a patient location and a remote monitoring device having the capability of receiving patient medical data from the patient monitoring apparatus. As shown in FIG. 2 of the Fu, et al. patent, the patient monitoring apparatus is provided in the form of a number of home units 60, each of which includes a number of sensors, including a blood pressure module 92, a scale module 84, a temperature module 86, and an ECG electrode unit 90. Each of the home units 60 is connected to a central unit 20 via a modem 62 connected to each home unit 60 and a modem 22 connected to the central unit 20. The Fu, et al. patent also generates medication reminders to a patient. See, for example, FIG. 13.

SUMMARY OF THE INVENTION

The invention is directed to a medical treatment apparatus having programmable medical treatment means for automatically administering a medical treatment directly to a patient, the programmable medical treatment means being disposed at a first room location, a sensor for detecting a medical condition of the patient, the sensor being disposed at the first room location and being connected to the patient, and a remote controller for controlling the programmable medical treatment means, the remote controller being disposed at a second room location remote from the first room location at which the programmable medical treatment means is disposed. The remote controller includes means for controlling the programmable medical treatment means to allow the medical treatment being administered to the patient to be changed, and the medical treatment apparatus also includes remote monitoring means operatively coupled to the sensor for monitoring the medical condition detected by the sensor, the remote monitoring means being disposed at the second room location.

The programmable medical treatment means may be an infusion pump for infusing a drug into the patient, the infusion pump being composed of a liquid injection device adapted to be connected to the patient, a conduit connected to the liquid injection device, a pumping mechanism for pumping a liquid drug through the conduit and into the patient via the liquid injection device, and a controller for controlling the pumping mechanism.

The invention is also directed to a method of administering a medical treatment to a patient via a programmable medical treatment apparatus. The method includes the steps of: (a) automatically administering a medical treatment to a patient with a programmable medical treatment apparatus disposed at a first room location, (b) detecting a medical condition of the patient with a sensor at the first room location, (c) transmitting medical condition data relating to the medical condition from the first room location to a second room location, and (d) transmitting a control command from the second room location to the programmable medical treatment apparatus at the first room location to change the medical treatment automatically administered during step (a), the control command being based upon the medical condition data transmitted during step (c).

The method may also include the step of analyzing the medical condition data prior to transmitting the control command, the step of displaying the medical condition data on a visual display disposed at the second room location, and the step of storing the medical condition data in the memory of a remote monitor/controller disposed at the second room location.

These and other features and advantages of the present invention will be apparent to those of ordinary skill in the art

in view of the detailed description of the preferred embodiment, which is made with reference to the drawings, a brief description of which is provided below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an apparatus for administering medical treatment to a patient and monitoring the condition of the patient;

FIG. **2** is a block diagram of the electronic components of the remote monitor/controller shown schematically in FIG. **1**;

FIG. **3** is a front view of one embodiment of the infusion pump shown schematically in FIG. **1**;

FIG. **4** is a block diagram of the electronic components of the infusion pump of FIG. **3**;

FIG. **5** is a flowchart of the overall operation of the infusion pump;

FIG. **6** illustrates a number of data-recording steps performed during the operation of the infusion pump;

FIG. **6A** is a flowchart of a routine for storing patient condition data generated by the sensors of FIG. **1**;

FIG. **7** is a representation of a portion of the memory of the infusion pump;

FIG. **8** is a flowchart of a store data routine which can be used to store data relating to the operation of the infusion pump and data relating to the condition of a patient;

FIG. **9** is a flowchart of a routine which may be used to identify the type of infusion pump to which the remote monitor/controller is coupled;

FIG. **10** is a flowchart of a main operating routine of the remote monitor/controller;

FIGS. **11A–11B** illustrate portions of visual displays generated by the remote monitor/controller;

FIG. **12** is a flowchart of a command pump routine that is performed by the remote monitor/controller;

FIG. **13** is a flowchart of a receive routine that is performed by the infusion pump;

FIG. **14** is a flowchart of a transmit routine that is performed by the infusion pump; and

FIG. **15** is an illustration of a graphical user menu that may be displayed by the remote monitor/controller.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. **1** illustrates one embodiment of an apparatus **10** for administering medical treatment to a patient and monitoring the condition of the patient. Referring to FIG. **1**, the apparatus **10** includes a programmable medical treatment means in the form of an infusion pump **12**, which is connected to a liquid medicant injection device in the form of a catheter **14** via a liquid conduit schematically shown as **16**.

The apparatus **10** includes a remote monitor/controller **20** which is disposed at a room location remote from the room location at which the infusion pump **12** is located. The remote monitor/controller **20** could be disposed in a different room of the same building in which the pump **12** is disposed, or in a different building than the one in which the pump **12** is disposed. The remote monitor/controller **20** is connected to a conventional voice/data modem **22** via a data link **24**, and the modem **22** is also connected to a telephone **26** via a voice link **28**. The infusion pump **12** is connected to a conventional voice/data modem **30** via a data link **32**, and the modem **30** is connected to a telephone **34** via a voice link **36**. The two modems **22**, **30** are interconnected to bidirectional voice and data communication via a communication link **38**, which could be a telephone line, for example.

The infusion pump **12** is connected to five conventional sensors which are connected to the patient and which detect various medical conditions of the patient. The sensors include a thermometer **40** connected to the infusion pump **12** via a line **42**, a blood pressure sensor **44** connected to the pump **12** via a line **46**, a blood gas sensor **48** connected to the pump **12** via a line **50**, a pulse rate sensor **52** connected to the pump **12** via a line **54**, and a blood-oxygen sensor **56** connected to the pump **12** via a line **58**. Not all of the sensors **40**, **44**, **48**, **52**, **56** are required for operation of the apparatus **10**, and other types of sensors could be used.

FIG. **2** is a block diagram of the electronics of the remote monitor/controller **20** shown schematically in FIG. **1**. Referring to FIG. **2**, the remote monitor/controller **20** includes a microprocessor (MP) **60**, a read-only memory (ROM) **62**, a random-access memory (RAM) **64**, and an input/output (I/O) circuit **66**, all of which are interconnected by an address/data bus **68**. The microprocessor **60** has a transmit buffer (XMIT) **70** for transmitting data bytes and a receive buffer (REC) **72** for receiving data bytes. The remote monitor/controller **20** has a keyboard **74** connected to the I/O circuit **66** via a line **76**, a display device **78**, such as a CRT, connected to the I/O circuit **66** via a line **80**, and an input device, such as an electronic mouse **82**, connected to the I/O circuit **66** via a line **84**. The remote monitor/controller **20** can also include one or more disk drives, such as a hard disk drive or a floppy disk drive.

FIG. **3** is a front view of one embodiment of the infusion pump **12** shown schematically in FIG. **1**. Referring to FIG. **3**, the pump **12** has an input device in the form of a keypad **90** via which a user may input data and commands and a display **92** for displaying textual messages to the user.

A block diagram of the electronics of the infusion pump **12** is shown in FIG. **4**. Referring to FIG. **4**, the pump **12** includes a controller **100**, an electrically programmable read-only memory (EPROM) **102** having a built-in I/O interface **102***a*, a nonvolatile RAM **104**, a real-time clock **106** and the display **92**, all of which are interconnected by a communications bus **108**. The display **92** has a backlight **110** which is selectively activated by an enable signal generated on a line **112** interconnecting the controller **100** and the backlight **110**. Both the RAM **104** and the real-time clock **106** are connected to a battery **114** which supplies power to them only in the absence of system power. The controller **100** has a transmit buffer **116** and a receive buffer **118** connected to the communications bus **108**.

The controller **100** controls the medicant infusion rate by periodically transmitting a control signal to an amplifier circuit **120** via a line **122** to drive a pump motor **124** which drives a pumping mechanism **126**, such as a rotary pump wheel (not shown) adapted to make contact with a portion of the liquid conduit **16** (FIG. **1**) connected to the catheter **14**.

The controller **100** receives periodic inputs from a shaft encoder (SE) sensor **130**, which is disposed on the shaft of the motor **124**. The SE sensor **130** may be a two-phase motion sensing encoder which provides two signal outputs to the controller **100**. The rotational speed of the motor **124** and its direction of rotation are determined by the controller **100** based upon the rate and phase relationship between the two signal outputs.

The SE encoder **130** periodically transmits the signals to the controller **100** via a line **132**. Each time the signals are transmitted, an interrupt is generated, and the controller **100**

compares the actual position of the motor shaft with its desired position, and transmits a new control signal, such as a pulse-width modulated signal, to the amplifier **120** via the line **122** to ensure that the actual speed of the motor **124** corresponds to the motor speed required for the desired medicant infusion rate. The interrupts caused by the SE sensor **130** are assigned to the highest priority so that they are responded to immediately, before any other actions are taken by the controller **100**.

The pump **12** has a number of other features not described herein, which are disclosed in the following patent applications, each of which is incorporated herein by reference: U.S. Ser. No. 08/399,184, filed Mar. 6, 1995, entitled "Infusion Pump Having Power Saving Modes"; U.S. Ser. No. 08/398,977, filed Mar. 6, 1995, entitled "Infusion Pump With Selective Backlight"; U.S. Ser. No. 08/398,980, filed Mar. 6, 1995, entitled "Infusion Pump With Different Operating Modes"; U.S. Ser. No. 08/398,886, filed Mar. 6, 1995, entitled "Cassette For An Infusion Pump; U.S. Ser. No. 08/399,183, filed Mar. 6, 1995, entitled "Infusion Pump With Dual-Latching Mechanism"; U.S. Ser. No. 08/398,887, filed Mar. 6, 1995, entitled "Infusion Pump With Historical Data Recording."

The operation of the infusion pump **12** is controlled by a computer program stored in the EPROM **102** and executed by the controller **100**. A flowchart **200** of the overall operation is illustrated in FIG. **5**. Referring to FIG. **5**, when the pump **12** is turned on, at step **202** the pump is initialized and a test of the pump operation is performed. The pump **12** may be turned off temporarily during an infusion, in which case the pump **12** may continue the infusion when it is turned back on, as described below. At step **204**, if there is any remaining volume of liquid to be infused by the pump or any additional time remaining for an infusion, which would be the case where the pump was temporarily turned off during an infusion, the program branches to step **206**, where the user is asked, via a message displayed on the display **92**, whether the previous infusion should be resumed. If the user answers yes (via the keypad **90**), the program branches to a ready-to-run step **210**. If the previous infusion is not to be resumed, the program branches to step **212**.

The infusion pump **12** has a lockout mode in which the user may be prevented from programming the infusion parameters, such as the volume to be infused or the rate of infusion. For example, the pump **12** could be programmed by a medical assistant to deliver a particular infusion having a particular flow profile, flow rate and volume to be infused. After programming that infusion, the medical assistant could place the pump in lockout mode, which would prevent the patient from changing any of the infusion parameters. At step **212**, if the pump **12** has been previously placed in lockout mode, the program branches directly to the ready-to-run step **210**, bypassing all programming steps.

At step **212**, if the pump is not in lockout mode, the program branches to step **214**, at which point the program prompts the user, via the display **92**, to input whether the patient should be allowed to program the pump during the subsequent infusion. If the pump is not to be programmable, the program branches to step **216** where a lockout sequence is performed by requesting the user to input which infusion modes should be locked out. If the pump is to be programmable by the patient, the program bypasses step **216**.

The infusion pump **12** has five basic modes of infusion: 1) a continuous mode in which the pump delivers a single volume at a single rate; 2) an auto-ramp mode in which the pump delivers liquid at a rate that gradually increases to a threshold rate, stays constant at the threshold rate, and then gradually decreases; 3) an intermittent mode in which the pump delivers discrete liquid volumes spaced over relatively long periods of time, such as a liquid volume every three hours; 4) a custom mode in which the pump can be programmed to deliver a unique infusion rate during each of 25 different time periods; and 5) a pain-controlled analgesic (PCA) mode during which the pump will periodically infuse boluses of analgesic in response to periodic requests by the patient.

At step **218**, the pump **12** generates on the display **92** the prompt "Continuous?" to the user. If the user desires to use the pump in its continuous mode, the user answers "yes" via the keypad **90**, and the program branches to step **220** at which the continuous mode is programmed by the user by entering a number of infusion parameters, such as the desired infusion rate, the volume to be infused, etc. At step **218**, if the user does not want to use the continuous mode, the user answers "No," and the program branches to step **222**. Steps **222–236** are generally the same as steps **218** and **220**, except that the user may be prompted for different infusion parameters, depending on which of the five possible infusion modes is selected.

After the completion of one of the steps **220**, **224**, **228**, **232**, or **236**, the program branches to the ready-to-run step **210**. When the user presses the "Run" key, the pump **12** enters the run mode **260** and infuses the patient with a liquid medicant in accordance with the infusion mode selected at one of steps **218**, **222**, **226**, **230**, **234** and the infusion parameters entered at one of steps **220**, **224**, **228**, **232**, **236**. The pump **12** remains in the run mode **260** until the "Hold" key is pressed, as determined at step **262**. Upon the occurrence of an alarm condition, an alarm is reported at step **264**. At step **262**, if the hold key is pressed, the infusion is stopped at step **266**, and the pump **12** waits for the run key to be pressed at step **268** or the on/off switch to be turned off at step **270**.

Summarizing the operation described above, if the pump is to be utilized in lockout mode, a medical assistant turns the pump on, programs the desired infusion mode at one of steps **220**, **224**, **228**, **232**, **236**, and then turns the pump off. The programmed infusion parameters will be retained in the memory **104**. The medical assistant would then turn the pump back on, press the "No" key in response to the "Programmable?" prompt at step **214**, enter the lockout information at step **216**, and then turn the pump off again. When the patient subsequently turned on the pump to perform the infusion, the program would proceed from step **212** directly to the ready-to-run step **210**, which would prevent the patient from altering the infusion parameters.

If the lockout mode was not utilized, the medical assistant or the patient could turn the pump on, program the desired infusion mode, and then press the "Run" key to start the infusion without ever turning the pump off.

During programming and operation, the infusion pump **12** automatically records in the non-volatile memory **104** all significant infusion data to generate a complete historical data record which can be later retrieved from the memory **104** and used for various purposes, including clinical purposes to aid in determining how effective a particular infusion therapy was and treatment purposes to confirm that the prescribed infusion was actually delivered.

FIG. **6** illustrates various steps at which infusion data is recorded that are performed during the overall pump operation shown generally in FIG. **5**. The infusion data recorded in the memory **104** is set forth in Table 1 below. A number

of events which trigger the storage of data are listed in the left-hand column of Table 1, and the infusion data that is recorded upon the occurrence of each event is listed in the right-hand column of Table 1. The time at which the infusion data is recorded, which is determined by the real-time clock **106**, is also stored along with the infusion data.

TABLE 1

EVENT	DATA RECORDED
Power On	Date and Time
Program	Infusion parameters. See TABLE 2.
Run	Infusion parameters. See TABLE 2.
Hold	Total Volume Infused
Restart	Time of Restart
Rate Changes	Total Volume Infused, Rate, Volume
Alarms	Total Volume Infused, Alarm Type
Infusion Complete	Total Volume Infused
Malfunctions	Total Volume Infused, Malfunction Type
Resume	Infusion parameters. See TABLE 2.
Maintenance Date	Date
Patient ID	Patient ID Number
Serial No.	Serial Number
Language Change	New Language
Lockout	Modes Locked Out
Pressure Select	New Pressure Setting
Bolus Request	Given/Not Given, Bolus Amount
Titration	New Parameters
Power Off	Time of Power Off
Version No.	Software Version Number

Referring to Table 1 and FIG. **6**, when the power to the infusion pump **12** is turned on, the date and time of the power turn-on is recorded. When the pump is completely programmed pursuant to one of steps **220**, **224**, **228**, **232**, **236** (FIG. **5**) as determined at step **302**, the programmed infusion parameters are stored at step **304**, along with the time of such storage. The particular parameters that are stored depend upon which infusion mode was programmed. Several examples of infusion parameters that are stored for each of a number of infusion modes are illustrated in Table 2 set forth below.

TABLE 2

INFUSION MODE	INFUSION PARAMETERS
Continuous	Infusion Mode
	Infusion Rate
	Volume To Be Infused
	Delay Time
	Total Bag Volume
	KVO Rate
Auto-Ramp	Infusion Mode
	Infusion Rate
	Volume To Be Infused
	Delay Time
	Total Bag Volume
	Duration of Up-Ramp
	Duration of Down-Ramp
	KVO Rate
Intermittent	Infusion Mode
	Total Infusion Time
	Number of Doses
	Dose Time
	Dose Volume
	KVO Rate

When the pump enters the run mode **260** (FIG. **5**) as determined at step **306**, the time at which the run mode was begun, along with the parameters pursuant to which the infusion is performed, are stored at step **308**.

At step **310**, if the hold key is pressed, then the time at which the hold key was pressed along with the total volume infused at the time the hold key was pressed are stored at step **312**. The pump also stores any infusion rate changes, such as changes caused by switching from a continuous rate to a keep-vein-open (KVO) rate, or in the intermittent mode, changing from a KVO rate to a higher infusion rate, the presence of which are detected at step **314**. The new rate and the time at which the new rate started are stored at step **316**.

At step **318**, if any alarms are generated, the alarm type, the time at which the alarm occurred, and the total volume infused at the time of the alarm are recorded at step **320**. If the infusion is completed as determined at step **322**, the program branches to step **324** where the time at which the infusion was completed is stored along with the total volume infused. At step **326**, if there is a malfunction, the malfunction type, the time at which the malfunction occurred, and the total volume infused at the time of the malfunction are recorded at step **328**.

At step **330**, if the infusion is resumed (when the pump is turned back on after having been turned off during an infusion), the time at which the infusion is resumed along with the infusion parameters are stored at step **332**. Upon the completion of the programming of a lockout sequence as determined at step **334** (i.e. after step **216** of FIG. **5**), the time at which the programming of the lockout was completed is stored along with the infusion modes that were locked out. At step **338**, upon the detection of a bolus request, the time at which the bolus was requested is stored at step **340**, along with an indication whether the bolus was actually given and the amount of the bolus.

FIG. **6A** is a flowchart of a routine **350** for periodically storing patient medical condition data generated by the sensors **40**, **44**, **48**, **52**, **56** of FIG. **1** in the nonvolatile RAM **104**. Referring to FIG. **6A**, at step **352** the thermometer **40** is read, and at step **354** data generated by the thermometer **40** is stored in the RAM **104**. At step **356** the blood pressure sensor **44** is read, and at step **358** data generated by the sensor **44** is stored in the RAM **104**. At step **360** the blood gas sensor **48** is read, and at step **362** data generated by the sensor **48** is stored in the RAM **104**. At step **364** the pulse rate sensor **52** is read, and at step **366** data generated by the sensor **52** is stored in the RAM **104**. At step **368** the blood oxygen sensor **56** is read, and at step **370** data generated by the sensor **56** is stored in the RAM **104**. The routine **350** may be performed periodically, such as every minute for example. Other ways of reading the sensors could be utilized, and the particular manner in which the sensors are read is not considered important to the invention.

FIG. **7** illustrates the data organization of a portion of the RAM **104** in which infusion data (the data stored during the steps of FIG. **6**) and patient medical condition data (the data stored during the steps of FIG. **6A**) are stored. Referring to FIG. **7**, the infusion data is stored in a number of memory locations **372**, and the medical condition data is stored in a number of memory locations **374**. Data may be written to the memory locations **372** utilizing a pointer **376** which specifies the memory location at which data should be next stored.

FIG. **8** is a flowchart of a routine **380** for storing data in the memory locations **372**, **374**. Referring to FIG. **8**, at step **382** the pointer **376** is set to the address of the next memory location **372** in which data is to be stored. At step **384**, if the pointer **376** is at the last memory location in which data may be stored, the routine branches to step **386** where the pointer is set to the address of the first memory location in which data may be stored. As a consequence of steps **384**, **386**, the contents of the memory locations **372** are periodically overwritten with new data; however, the number of memory

locations **372** is sufficiently large so that several months of data, for example, is stored before being overwritten. At steps **388** and **390** the data is stored in the memory location **372** specified by the pointer **376** (the data includes a time stamp generated from the real-time clock **106** and event data specifying the particular infusion event). Data may be stored in the memory locations **374** in the same manner.

FIGS. **9**, **10**, and **12** are flowcharts of various routines that are performed by the remote monitor/controller **20**. As described in more detail below, the remote monitor/controller **20** may be used to monitor the operation of the infusion pump **12**, to control the operation of the infusion pump **12**, and/or to transfer infusion data and patient data from the infusion pump **12** so that such data can be reviewed by a health care professional at a location remote from the patient.

The remote monitor/controller **20** is designed to interface with different types of infusion pumps. In order to determine which type of infusion pump the remote monitor/controller **20** is operatively coupled, a pump identification routine **400** performed after the communication link between the remote monitor/controller **20** and the infusion pump **12** is established. Referring to FIG. **9**, at step **402** the remote monitor/controller **20** transmits a pump identification (ID) request to the infusion pump **12** via the communication link **38**. In response to the pump ID request, the pump **12** transmits a multi-character ID code back to the remote monitor/controller **20**. The ID code may include, for example, one or more characters identifying the pump model and/or one or more characters identifying the software version of the pump. At step **404**, the remote monitor/controller **20** reads the characters sent from the pump **12** until all characters are received as determined at step **406** or until a predetermined time period, e.g. five seconds, elapses. The time period may be determined by a timer (not shown). The remote monitor/controller **20** may determine that all characters have been received by, for example, identifying one or more termination characters, such as a carriage-return character <CR> followed by a line-feed character <LF>.

Step **408** determines whether a correct response was received from the pump **12**, which may be determined checking the characters received from the pump **12** against a list of possible ID codes. If a correct response was received, the routine branches to step **410** where the pump type is determined, for example, by comparing the received pump ID code with at least one possible ID code which identifies a particular type of infusion pump, or by comparing the received pump ID code with a number of possible ID codes, each of which identifies a particular type of infusion pump. As used herein, the "type" of infusion pump may relate to the model of the pump or the software version of the pump.

If a correct response was not received as determined by step **408**, at step **412** the routine determines whether the predetermined time period measured by the timer has expired prior to receiving a termination character. If so, the routine branches to step **414** where an error message is generated due to the pump's failure to respond to the pump ID request.

At step **412**, if some type of response (not a correct response) was received before the timer expired, the routine branches to step **416**. Steps **416–426** comprise a second way of determining the type of infusion pump **12** connected to the remote monitor/controller **20**, which is based on the number of characters in the display **92** of the pump **12**. For example, a first type of infusion pump may have a display capable of displaying **12** characters, whereas a second type of infusion pump may have a display capable of displaying **32** characters. Steps **416–426** determine the type of infusion pump based on the number of characters in the display.

At step **416**, the remote monitor/controller **20** transmits a pump display request to the infusion pump **12** to request the pump **12** to transmit the content of its display **92**. At step **418**, the remote monitor/controller **20** reads the display characters transmitted from the pump **12**. At step **420**, if a predetermined period of time has elapsed or if a terminating character is received, the routine branches to step **422**. At step **422**, if the predetermined time period measured by the timer elapsed prior to the receipt of a terminating character, the routine branches to step **424** where an appropriate error message is generated. At step **426**, the type of pump is determined based on the number of display characters that were received.

The routine could also exit step **420** if a predetermined number of characters are received. In that case, where the remote monitor/controller **20** was designed to interface with two different types of infusion pumps, one having a display capability of 12 characters and another having a display capability of 32 characters, if the remote monitor/controller **20** received more than 12 display characters at step **420**, it would immediately be able to determine that the pump type corresponded to a pump with a 32-character display capability.

The remote monitor/controller **20** allows four basic functions to be performed, including controlling the infusion pump **12**, monitoring the operation of the pump **12**, transferring infusion data and patient medical condition data from the pump **12** to the remote monitor/controller **20**, and viewing the data. The user may perform one of those functions by selecting an operational mode displayed on the display device **78** (FIG. **2**) of the remote monitor/controller **20** via the mouse **82**. These modes include a command mode in which a health care professional at the remote monitor/controller **20** may transmit command signals to the infusion pump **12** to control its operation, a monitoring mode in which the infusion pump **12** will continually transmit the contents of its visual display **92** to the remote monitor/controller **20**, a download data mode in which infusion data and/or patient medical condition data is transferred from the pump **12** to the remote monitor/controller **20**, and a view data mode in which the infusion data and patient data may be viewed on the display **78** of the remote monitor/controller **20**.

FIG. **10** illustrates a flowchart **450** of the basic operation of the remote monitor/controller **20**. Referring to FIG. **10**, at step **452**, if the user selected the command mode described above, the routine branches to step **454** where a display of the keypad **90** of the infusion pump **12** is shown on the display device **78**. The display shown at step **454** comprises a plurality of virtual entry keys having a spatial configuration substantially the same as the entry keys of the keypad **90** of the particular infusion pump type which is connected to the remote monitor/controller **20**. An example of such a visual display is shown in FIG. **11A**.

It should be noted that the virtual keypad shown in FIG. **11A** is the same as the actual keypad **90** of the pump **12**, which is shown in FIG. **3** (except that the on/off key of the pump **12** is replaced with a reset key in the virtual key display). Where a different type of pump having a different keypad is attached to the remote monitor/controller **20**, that particular keypad is displayed on the display device **78**. An example of a different virtual keypad is shown in FIG. **11B**. Various virtual keypad configurations may be stored in the memory of the remote monitor/controller **20**, each virtual

keypad configuration having a pump type code associated therewith. Since the remote monitor/controller **20** initially determined the type of pump to which it was attached (via the routine of FIG. **9**), it can retrieve from memory and display the corresponding virtual keypad for that type of pump.

After the virtual keypad is displayed, the health care professional may control the operation of the infusion pump **12** by selecting any of the virtual keys with the mouse **82**. Other ways of selecting the keys could be utilized, such as a touch-sensitive screen or a display screen activated by radiation sensors. The infusion pump **12** responds to commands entered via its keypad **90** and to commands generated from the remote monitor/controller **20**. At steps **456** and **458**, any commands entered by the health care professional are transmitted to the infusion pump **12**, and at steps **460** and **462**, the display of the pump **12** is transferred to the remote monitor/controller **20** and displayed on the display device **78** of the remote monitor/controller **20**. At step **464**, if the user exits the command mode, the routine branches back to step **452**.

At step **465**, if the health care professional selected the monitor mode, the routine branches to step **466** where a visual display of the pump display **92** is shown on the display device **78**. At step **467**, the contents of the pump display **92** are transferred to the remote monitor/controller **20**, and at step **468** those contents are displayed in the visual display generated at step **466**. At step **469**, if the user exits the monitor mode, the routine branches back to step **452**; otherwise, the routine branches back to step **467** so that the contents of the pump display **92** are continuously shown on the display device **78** at step **468** (the display **92** of the infusion pump **12** changes in accordance with the pump operation so that the pump operation can be monitored by viewing the display **92**). Step **467** may be accomplished, for example, by transmitting a pump display request to the pump **12** (via steps similar to steps **416–420** described above).

If the health care professional inputs a request to download data from the pump **12** to the remote monitor/controller **20** as determined at step **470**, the routine branches to step **472** where the data transfer is accomplished, as described below in connection with FIGS. **13–14**. If the user inputs a view data log request as determined at step **474**, the routine branches to step **476** where data previously downloaded at step **472** can be viewed on the display device **78** of the remote monitor/controller **20**. The user may exit the mode select routine **450** via step **478**.

FIG. **12** illustrates one routine that could be used to implement the transmit command step **458** shown schematically in FIG. **10**. Referring to FIG. **12**, the pump command is transmitted from the remote monitor/controller **20** at step **480**, and then the infusion pump **12** transmits to the remote monitor/controller **20** an echo of the command so that the remote monitor/controller **20** knows that command was received properly by the pump **21**. The characters making up the echo are received at steps **482–484**, and if the echo is not correct, an error message is displayed to the health care professional. At step **490**, the remote monitor/controller **20** sends an acknowledgement of the echo to the pump **12**.

The transfer of data from the infusion pump **12** to the remote monitor/controller **20** shown schematically in step **468** of FIG. **10** is accomplished via a receive interrupt service routine **500** and a transmit interrupt service routine **550** that are performed by the infusion pump **12**. Flowcharts of the routines **500**, **550** are shown in FIGS. **13** and **14**.

The receive routine **500** shown in FIG. **13** is invoked upon the generation of a receive interrupt by the pump controller **100**. The receive interrupt indicates that a message has been received in the receive buffer **118** of the controller **100** from the remote monitor/controller **20**. When a download data command is sent to the infusion pump **12** (as determined at step **466** of FIG. **10**), a data dump flag is set to logic "1," indicating that a data transfer or dump from the pump **12** to the remote monitor/controller **20** is in progress. The data transfer is performed in a segmented fashion. Instead of sending all of the infusion data and patient data stored in the RAM **104** to the remote monitor/controller **20** in a single, continuous stream, the data is sent in segmented portions, each of which is separated in time from its adjacent portions by a period of time, e.g. 100 microseconds.

Referring to FIG. **13**, when the routine begins at step **502**, a character or message will have been just received in the receive buffer **118**. At step **502**, if the data dump flag is active, meaning that a data transfer is already in progress, then the routine branches to step **504**, where the data dump flag is set to logic "0," effectively terminating the data dump operation, and an error message is transmitted to the remote monitor/controller **20** at step **506**. This is done to prevent the data dump operation from interfering with any commands that are transmitted from the remote monitor/controller **20** to the infusion pump **12**.

If the data dump flag was not active as determined at step **502**, the routine branches to step **508** where the message just received in the receive buffer **118** is checked to determine whether it is a data dump command. If it is not, then the routine branches to step **510** where the pump **12** responds to the command.

If the message is a data dump command, the routine branches to step **512** where a transmit pointer **513** (see FIG. **7**) is set to the oldest data in the RAM **104** that has not yet been transmitted to the remote monitor/controller **20**. At step **514**, the data dump flag is set to logic "1" since a new data transfer operation is beginning. At step **516**, the data byte specified by the transmit pointer **513** is retrieved from the RAM **104**, and at step **518** the position of the transmit pointer **513** is updated (e.g. incremented) to point to the address of the next data byte to be transmitted. At step **520**, the data byte retrieved at step **516** is formatted in ASCII; at step **522** the transmit interrupt is enabled; and at step **524** the reformatted data byte is transmitted from the infusion pump transmit buffer **116** to the remote monitor/controller **20** over the data link **38**.

When the first data byte is sent out from the transmit buffer **116**, a transmit interrupt is generated by the controller **100** to indicate that the transmit buffer **116** is empty and that another data byte can be transmitted. Upon the generation of the transmit interrupt, the transmit routine **550** is performed. Referring to FIG. **14**, at step **552** the status of the data dump flag is checked. If the flag is not active, meaning that a data dump operation is not in progress, the routine branches to step **554** where the routine responds to the other interrupt. If the data dump flag is active, then the routine branches to step **556**, where it determines whether all of the segmented portions of the infusion data and/or patient data have been transmitted. This may be accomplished, for example, by determining if the transmit pointer **513** and the pointer **376** (FIG. **7**) are pointing to the same memory location. If all the requested data has been sent, the routine branches to step **558**, where the transmit interrupt is disabled, and then to step **560** where the data dump flag is reset to logic "0," effectively ending the data transfer operation.

If not all the data has been transferred as determined at step **556**, the routine branches to step **562** where the data byte specified by the transmit pointer **513** is retrieved from

the RAM **104**. At step **564** the position of the transmit pointer is updated to point to the address of the next data byte to be transmitted. At step **566**, the data byte retrieved at step **562** is formatted in ASCII, and at step **568** the reformatted data byte is transmitted from the infusion pump transmit buffer **116** to the remote monitor/controller **20** over the data link **38**.

The transmit interrupts generated by the controller **100** to transfer the segmented data portions to the remote monitor/controller **20** are assigned a lower priority than the interrupts generated in response to input of the shaft encoder sensor **130**, which is necessary to provide the desired infusion rate. Consequently, the transfer of the infusion data and patient data does not interfere with the ability of the pump **12** to provide the desired infusion rate, and the data transfer can occur while the pump is infusing the patient with the medicant.

FIG. **15** is an illustration of a graphical user menu that may be shown on the display device **78** of the remote monitor/controller **20**. The health care professional may select particular data for transfer or viewing, via a number of different parameters such as beginning date, ending date, types of data, etc. The particular manner in which particular data may be selected for transfer or viewing is not considered important to the invention.

The ability to generate patient medical condition data via the sensors **40**, **44**, **48**, **52**, **56** and transfer that data to the remote monitor/controller allows a health care professional to review and analyze the patient medical condition data and alter the infusion therapy applied to the patient by the infusion pump **12** based upon such review and analysis. Alternatively, instead of such manual analysis by a health care professional, an automatic means for analyzing the patient medical condition data and altering the infusion therapy could be provided.

Modifications and alternative embodiments of the invention will be apparent to those skilled in the art in view of the foregoing description. This description is to be construed as illustrative only, and is for the purpose of teaching those skilled in the art the best mode of carrying out the invention. The details of the structure and method may be varied substantially without departing from the spirit of the invention, and the exclusive use of all modifications which come within the scope of the appended claims is reserved.

What is claimed is:

1. A medical apparatus, comprising:

a programmable medical device disposed at a first room location;

a sensor for detecting a medical condition of a patient, the sensor being disposed at the first room location, being connected to the patient and being connected to the programmable medical device;

wherein the programmable medical device comprises a memory storing medical condition data relating to the medical condition of the patient detected by said sensor; and

a remote controller for controlling the programmable medical device, the remote controller being disposed at a second room location remote from the first room location at which the programmable medical device is disposed, the remote controller comprising:

a controller for controlling the programmable medical device; and

a remote monitor operatively coupled to the sensor via said programmable medical device effective for retrieving stored medical condition data from the memory for monitoring the stored medical condition detected by the sensor.

2. The medical apparatus according to claim **1** wherein the sensor comprises at least one of a blood pressure sensor, a blood gas sensor, a pulse rate sensor and a blood-oxygen sensor.

3. The medical apparatus of claim **1** further comprising a routine for transmitting said stored medical condition data detected by said sensor, responsive to a data dump command.

4. An apparatus as defined in claim **1** further comprising a routine for transmitting medical condition data relating to said medical condition of the patient detected by the sensor from the first room location to the remote monitor at said second location.

5. An apparatus as defined in claim **1** wherein the programmable device comprises an infusion pump for infusing a drug into the patient.

6. An apparatus as defined in claim **1** wherein the programmable medical device comprises:

a liquid injection device adapted to be connected to the patient;

a conduit connected to the liquid injection device;

a pumping mechanism for pumping a liquid drug through the conduit and into the patient via the liquid injection device; and

a controller for controlling the pumping mechanism.

7. An apparatus as defined in claim **1** wherein the sensor generates an output signal representative of the condition of the patient and wherein the output signal is input to the programmable medical device.

8. A medical apparatus, comprising:

programmable medical treatment device for automatically administering a medical treatment directly to a patient, the programmable medical treatment device being disposed at a first room location, the programmable medical treatment device comprising:

a liquid injection device adapted to be connected to the patient;

a conduit connected to the liquid injection device;

a pumping mechanism for pumping a liquid drug through the conduit and into the patient via the liquid injection device; and

a controller for controlling the pumping mechanism;

a sensor for detecting a medical condition of the patient, the sensor being disposed at the first room location and being connected to the patient and to the programmable treatment device;

wherein the programmable medical treatment device further comprises a memory storing medical condition data relating to the medical condition of the patient detected by the sensor;

a remote controller for controlling the programmable medical treatment device, the remote controller being disposed at a second room location remote from the first room location at which the programmable medical treatment device is disposed, the remote controller comprising

a controller for controlling the programmable medical treatment device; and

a remote monitor operatively coupled to the sensor via the programmable medical treatment device effective for retrieving the stored medical condition data from the memory for monitoring the medical condition detected by the sensor; and

apparatus for transmitting the stored medical condition data relating to the medical condition of the patient detected by the sensor from the first room location to the remote monitor.

9. A medical apparatus according to claim **8** wherein the sensor comprises at least one of a blood pressure sensor, a blood gas sensor, a pulse rate sensor and a blood-oxygen sensor.

10. An apparatus as defined in claim **8** wherein the remote monitor comprises a display for displaying the medical condition data.

11. An apparatus as defined in claim **8** wherein the sensor generates an output signal representative of the condition of the patient and wherein the output signal is input to the programmable medical treatment device.

12. A medical apparatus comprising:

a medical treatment device for administering a medical treatment directly to a patient at a patient site, the medical treatment device being disposed at the patient site;

a sensor disposed at the patient site for detecting a medical condition of the patient, the sensor being connected to the patient and to the medical treatment device;

wherein the medical treatment device includes a memory storing medical condition data relating to the medical condition of the patient detected by the sensor;

a remote controller at a second location remote from the patient site for controlling the medical treatment device, the remote controller comprising a device for controlling the medical treatment device to change the medical treatment administered to the patient; and

a remote monitor disposed at the second location operatively coupled to the sensor via a telephone link and the medical treatment device effective for retrieving the stored medical condition data from the memory for monitoring the medical condition detected by the sensor.

13. The medical apparatus of claim **12** further comprising apparatus for enabling bi-directional voice data communication over the telephone line between the medical treatment device and the remote controller.

14. The medical apparatus according to claim **12** wherein the sensor comprises at least one of a blood pressure sensor, a blood gas sensor, a pulse rate sensor and a blood-oxygen sensor.

15. The medical apparatus as defined in claim **12** wherein the medical treatment device comprises a programmable infusion pump for infusing a drug into the patient.

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